Washington State Sensitive Groundwater Mapping Project

Marie Mills, GIS Specialist,
Albert Perez, GIS Analyst,
Shari Schaftlein, Water Quality Program Manager
Environmental Affairs Office
Washington State Dept. of Transportation
Olympia, WA

INTRODUCTION

Washington State Department of Transportation (DOT) has compiled a database of sensitive groundwaters throughout the State for use in a Geographical Information System (GIS). This 18-month, Environmental Protection Agency Clean Water Act grant-funded project, includes the layers: sole source aquifers, critical aquifer recharge areas, and wellhead protection zones for Group A public water supply wells.

Critical Aquifer Recharge Areas (CARA) are those areas with a critical recharging effect on aquifers used for potable water. Sole Source Aquifers (SSA) are underground waters that supply at least 50 percent of the drinking water for persons living over the aquifer where there are no other economically feasible sources of drinking water that could replace the aquifer and there are clearly definable aquifer boundaries. Wellhead Protection Zones (WPZ) are management areas based on established time of horizontal travel in the surrounding aquifer.

SSA data currently exists and was provided from the Environmental Protection Agency (EPA). CARAs, delineated by each county in compliance with the Growth Management Act, were provided in various formats. WPZ data was delineated by each well system owner in compliance with the Safe Drinking Water Act and collected in various formats from Washington State Department of Health (DOH) and individual system owners.

This data is to be used by DOT and other state Interagency Groundwater Committee (IGWC) members as a planning tool in managing and protecting the State's drinking water supply. At DOT the following activities are in need of groundwater sensitivity data on a regular basis: h Stormwater Management, Hazardous Waste Clean Up, Emergency Response, Wetland Mitigation Planning, Geotechnical Investigations, Roadside Vegetation Management, Construction Management, and Environmental Documentation. The IGWC has served as advisor to DOT for this EPA funded project. This data will be available by July of 1997 as either ArcInfo coverages or ArcView shapefiles.

State highways intersect all counties, and transportation projects have the potential to affect the environment statewide. This agency is the largest developer in the State, directing the greatest amount of dollars towards mitigation. The agency must determine statewide priorities and evaluate the

State Transportation Plan for potential environmental impacts. Transportation improvements are based on analysis at the planning scale level. Further design detail and mitigation is based on a watershed approach. DOT received this grant because of the project-oriented nature of the agency.

This grant was used to hire a GIS Specialist within the Environmental Affairs Office. This project allowed the Environmental Office to take advantage of the "user-driven" approach to implement GIS within the agency.

DATA USES

Water Quality

Critical aquifer recharge and well capture zone data can be used to aid and influence design and planning decisions regarding stormwater facilities constructed in conjunction with highway improvement projects:

1. Treatment and disposal system design. Need and efficacy of pretreatment systems for stormwater runoff may be selected if stormwater is discharged to groundwater via infiltration or direct discharge using dry wells.

2. Stormwater retrofit project prioritization. Existing stormwater conveyance and disposal systems are prioritized for construction retrofit treatment system and/or conveyance systems redesigns.

Hazardous Materials

Sensitive groundwater GIS data layers can be a useful tool when assessing the impacts of potentially contaminated properties on transportation projects. They are also useful in helping to develop site-specific, risk-based cleanup standards for individual sites.

During the environmental documentation phase of a project it is necessary to assess the hazardous waste impacts which may be encountered during the construction and operation of the facility. Facilities located in sensitive groundwater areas may require special design considerations, such as the use of storm water retention ponds as opposed to infiltration basins. Excavations in contaminated areas may expose contaminants or change their migration pathways creating impacts to groundwater that may not have existed before the construction of the project. For instance, certain soil types, such as clay, form a natural barrier to prevent contamination of groundwater. If the project removed this layer, the potential for groundwater contamination from spills could be greater. Knowing the potential for groundwater contamination enables the project designers to develop mitigation strategies.

These layers are also useful for developing cleanup strategies for contaminated properties. The recent trend in environmental cleanups has been to develop site-specific cleanup standards based upon the actual risk of the specific contaminant in its unique environment, rather than depending upon generic cleanup standards. Knowing the potential for groundwater contamination or recontamination is vital in determining what level of cleanup

is appropriate. Sites located in sensitive groundwater areas would require a greater level of cleanup than those in areas where groundwater contamination is not an issue.

Biology

There is a definite and complex link between groundwater and natural freshwater wetlands. Some wetlands receive their hydrology from groundwater discharge while others may contribute to groundwater recharge by detaining water while it slowly percolates into the aquifer. Understanding this relationship is important for assessing how a wetland functions.

Knowing where designated sensitive groundwater areas are located can aid in evaluating the local significance of a given wetland's water quality functions. This information can help in choosing project alternatives which have the least environmental impacts.

This could also be used in strategizing mitigation for unavoidable project impacts to ensure the maximum environmental benefit. For example, it may be beneficial to focus wetland mitigation, restoration, and creation efforts in areas where aquifer recharge is an identified resource need. This data could be used to help guide where and how wetland mitigation should be implemented.

Geotechnical

There is a need to avoid creating pollutant conduits to aquifers from improperly filled test wells or soil borings during geotechnical investigations.

Vegetation Management

For proper vegetation management, nutrient and pesticide application practices are to be described in Roadside Vegetation Management Plans, and will be altered as appropriate in sensitive groundwater areas.

PROJECT METHODOLOGY

A GIS Specialist was hired in 1995 to implement the Sensitive Groundwater Mapping Project. The EPA grant budget provided $69K for salary; DOT and DOE provided approximately $45K of in-kind match representing equipment, administrative costs, and funds directed to local governments in support of CARA and WPZ delineation. A work plan was written and presented to the Interagency Groundwater Committee (a committee of state agencies concerned with groundwater issues: Department of Health, Department of Ecology, Department of Agriculture) and the Geographic Information Council, (a forum of state and local agency and private industry GIS Managers for implementating GIS throughout the state) to receive feedback on project methodology and database design.

A representative group of end users was chosen as pilot study data testers; Clark and Thurston counties were selected as the pilot study areas. CARA and WPZ data was obtained, formatted and distributed as ArcInfo coverages, along with metadata in text file format. Most feedback was positive and all

users expressed a strong desire for this type of data to be available for analysis. Two issues of concern were noted: 1) CARA designation methodology and how it would affect a statewide data layer, and 2) metadata format.

During the course of the project it became clear that methods of designating CARAs vary widely between counties. The potential misuse of a statewide data layer comprised of such differently derived data was addressed by revising the work plan from creating one statewide data layer to creating individual CARA data layers for each county (see DATA - CARA section for further discussion).

Justification for not using ArcInfo's Document.aml metadata format was requested. Since not all users will have workstation ArcInfo available to them, the ArcView platform is most likely to be used when viewing this data. DOT has already adopted an agency-wide standard metadata format; this format was chosen for consistency of metadata within the agency. This format can be exported as a text file, which will be most accessible to the greatest number of users.

Once the work plan was presented, tested, and finalized, the primary task of the project focused on gathering data from each county. This required contacting the county and discussing the project, usually with the Planning Department staff. This component of the Groundwater project proved to be the most time consuming and interesting, as it enabled a query of GIS capabilities at the county level throughout the state.

By December of 1996 the use of GIS within the Environmental Affairs Office had grown tremendously, leaving the GIS Specialist little time for the Groundwater Project. A full-time GIS Analyst was hired to complete the project. The project status was presented in December 1996 to the NW Washington GIS User Group, hosted by Snohomish County, the Shoreline and Coastal Planners Group of Washington, and at the March and May 1997 meetings of the IGWC. Persons interested in receiving the data were encouraged to submit their request via email.

DOT met with Washington State Department of Health (DOH) in January to discuss an interagency partnership to improve upon the Groundwater Project data. DOH gave DOT $10,000 to further enhance the wellhead protection zone data layer and verbally agreed to give an additional $75,000 for enhancement and creation of GIS data layers related to drinking water protection.

TECHNICAL NOTES

Unix ArcInfo and PC ArcView constitute the standard GIS software within DOT, and were used for the Groundwater Project. Unix ArcInfo on IBM Risc 6000 computers is accessed from PC's using Hummingbird Exceed X-term emulator. Standardization of the database to a common format was

completed in INFO, while sample maps and analysis was done in ArcView for PC using an NT platform. PC's were equipped with 64 MB of RAM, VGA graphics cards and 21" monitors. ArcView performed in a reasonably stable manner and enabled users to produce sample maps quickly and easily. All data sets and ArcView project files were stored and accessed on a local server.

DATA LAYERS

Sole Source Aquifers

This data has already been created and is available from the EPA.

Wellhead Protection Zones

The Washington State Department of Health requires well purveyors to establish one-year, five-year and ten-year time-of-travel zones. Within the one-year zone, water purveyors strive to protect the drinking water supply from viral, microbial, and direct chemical contamination. Within the five-year zone, the goal is to control potential chemical contaminants. Within the ten-year zone, high risk operations and facilities are identified, and steps taken to reduce contaminant loading. Time-of-travel zones may be delineated using a Calculated Fixed Radius Method, Analytical Methods, Hydrogeologic Mapping Methods, or Numerical Flow/Transport Models.

The GIS Specialist began collecting data for this layer by contacting each county's Planning Department and requesting the data or data contact for well systems. This proved to be a cumbersome process. Many counties did not have wellhead protection zone data and most well system owners, even for Group A wells (drinking water wells with 15 or more connections) used the calculated fixed radius method, did not have data in digital format and did not have the well points or zones mapped in a format that could be easily digitized.

It quickly became evident that DOH held the greatest amount of well and well system information throughout the state and that approaching one source for the data would yield the best results within the time constraints of the project. DOT met with DOH to discuss available data sets. Although DOH has a mainframe database of all well points used for drinking water, many of the well points lacked accurate location data. Only some well points had a latitude/longitude coordinate, while most were located only by Township, Range, Section, and quarter section. A more definite location was needed to make the data usable in GIS.

Although the scope of this project was not to create a data layer of public drinking water supply wells, the benefit of comparing this data to the wellhead protection zone data layer was recognized. Department of Ecology also had a strong desire for a GIS compatible well point data layer for their Aquifer Vulnerability Project. DOE and DOH combined efforts to generate a location point for each well. The data was run through a program to generate

an x,y location within the center of each quarter section for those well points without a latitude/longitude available.

This resulting GIS well point data layer was used to generate wellhead protection zones throughout the state based on calculated fixed radius measurements submitted by well system owners to DOH. This data layer will provide a tool for statewide assessment of potential impacts to Group A wells. Additional moneys received and promised from DOH will provide resources to integrate wellzone data from those counties using more advanced methodologies to determine their wellhead protection zones. A proposal for increasing the accuracy of Group A public water supply wells within counties of high population density around Puget Sound has been submitted to EPA as part of their Locational Data Improvement Project and would further enhance well point and wellhead location accuracy.

Critical Aquifer Recharge Areas

The State of Washington Growth Management Act (GMA) required each county in the state of Washington to designate Critical Areas by September 1, 1991. Critical areas include, among other things, areas with a critical recharging effect on aquifers used for potable water, otherwise known as Critical Aquifer Recharge Areas. Administrative guidelines of the GMA recommend that affected counties and cities use existing studies on aquifers and their recharge areas as the basis for classifying and designating these areas. Where no specific studies have been done, counties and cities may use existing soil and surficial geologic information to determine where recharge areas are. As a result, the approach to CARA designation is different in each county.

The Critical Areas Ordinances (CAO) were discussed with each county's Planning Department in conjuction with requesting data. The CAO is a mandatory requirement of the GMA, designating Critical Areas within the county, including CARAs. Thirty-two of the thirty-nine counties in Washington have adopted CAOs. Most, but not all CAOs address CARA designation, as required by the GMA.

The Washington State Department of Community, Trade and Economic Development, which oversees county compliance with the Growth Management Act, does not require that designated CARAs be mapped. Counties that designated CARAs in their CAO, but did not map them include: Adams, Columbia, Grays Harbor, and Skamania.

Examples of CARA designation:

- In Kitsap County, the following factors were used to establish general criteria for designating CARAs:

1) Surface soils characteristics- the permeability of the soil and its ability to transmit or retard contaminants.

2) Wellhead protection zones around Group A Water System supply wells- one year time of contaminant travel.
3) Areas with high concentrations of group B water systems (less than 15 connections) and private domestic wells.

- In King County, areas meeting the following criteria were designated as CARAs:

1) Sole Source Aquifers.
2) Areas where aquifers are used for drinking water that has permeable soils or subsurface geology and the groundwater is near the surface.
3) Wellhead Protection Areas for municipal or district drinking water systems.

- Pierce County evaluated ground water pollution potential for the entire county using the DRASTIC model based on hydraulic conductivity, depth to water, net recharge, topography, aquifer media and soil media. Areas that received a DRASTIC rating of 180 and above were designated as CARAs. In addition, the entire Clover/Chambers Creek Aquifer was designated a CARA.

- Grays Harbor County's CAO designates the following as CARAs:

1) Watershed areas upstream of existing impoundment and pumping structures associated with the City of Hoquiam and City of Aberdeen surface water supplies.

2) The protective 100-foot radius around Group A and B (public) water wells required by the Washington State Department of Health.

Grays Harbor does not plan to map CARAs at this time. The Grays Harbor CAO states that designation of other CARAs was postponed due to 1) a lack of reliable data, and 2) the absence of any observations of significant degradation of water quality anywhere in the county.

Unmapped Counties
Some rural Washington counties, such as Asotin, Columbia, Garfield, Kittitas, Skamania, and Wahkiakum counties have small populations and limited resources to designate and map CARAs. Garfield County has no Planning Department, and has hired a consultant to draft its CAO. Stevens County has a Geographic Information System, but had to lay off the staff needed to run it last year due to budget cuts; they are not capable of mapping their CARAs at this time.

CARA Status
By the Groundwater Mapping Project due date of June 30, 1997, 16 counties will be formatted and ready for use. Twelve of these counties had their CARA data in digital format initially: Clark, Clallam, Island, Mason,

Jefferson, Lincoln, King, Kitsap, Pierce, Spokane, Thurston and Whatcom. Three counties forwarded paper maps which DOT digitized: Pend Orielle, Ferry and Franklin. One county, Lewis, based its CARA on Department of Natural Resources (DNR) soils and an ArcInfo cross reference table. DNR gave the soils to data to DOT in exchange for the completed Groundwater Project data.

Six additional counties are creating digital CARA data or are in the process of sending the data at the time of this writing. These include Benton, Cowlitz, Pacific, Skagit, Snohomish and Walla Walla. It is hoped that some of these data layers will be available to DOT and included in the project.

Seventeen counties will not have data available by the project due date. San Juan county CARA is based on soils maps that are difficult to digitize, and would produce poor quality data.

Five counties plan digital maps at some time in the future. Grant County projects that its CARA maps will be completed by December 1997. Okanogan County plans to complete their CARA maps by 1999. Chelan, Douglas, and Okanogan counties are planning to create digital CARA maps, but the time frame for completion is uncertain.

The remaining eleven counties have no plans to map their CARAs, because they are constrained by resources and/or a lack of what they consider reliable data. Adams, Columbia, Grays Harbor, Skamania, Kittitas, Whitman and Yakima counties have implemented, or are moving toward, designation of Critical Aquifer Recharge Areas via ordinance language that specifies particular land uses requiring detailed analysis of potential impacts on groundwater. Asotin, Garfield, Stevens and Wahkiakum counties have yet to adopt Critical Areas Ordinances, and have no plans to create CARA maps, digital or otherwise, at this time.

It may be possible to use soils geologic or other data, to generate approximate aquifer recharge areas in counties that have not mapped their CARAs. Although this type of data would not carry the weight of official county CARA designtation, it would provide some information to guide assessment of potential impacts to ground water.

Variations in database design between counties have posed a challenge in creating a uniform data framework statewide without losing valuable data elements. For example, some counties differentiate between High, Medium, and Low CARAs, while others simply designate CARAs as existing or not. In consultation with DOT's Water Quality Specialists, it was decided to retain all data elements provided by the counties, and to add a new field, "CARA" that will carry the information on critical aquifer status. Data users will be able to perform simple analysis with the CARA field, or more complex analysis using the other fields in those counties where it is available.

Initially, one of the goals of the project was to assemble a statewide CARA data layer. However, as we learned more about the requirements of the GMA it became clear that the CARA designation methodology varied too much to combine each county in one database without potential misinterpretation of the data. For example, often CARAs designated in one county stop at the county line and do not continue into the next.

The decision was made to keep each county coverage separate. All of the original county data was retained in each coverage, and a new "CARA" item was added. In this way, the original county data, which is related to that county's methodology, would be available for more sophisticated analysis. Metadata will be distributed with each county data set, in order to facilitate appropriate use of the data.

It may be possible to use soils, geologic, or other data to generate approximate aquifer recharge areas in counties that have not mapped their CARAs. Although this type of data would not carry the weight of official county CARA designtation, it would provide some information to guide assessment of potential impacts to ground water.

DATA DISTRIBUTION

With few exceptions data obtained for this project was received free of charge. In turn, the data will be available to all interested parties without cost unless the cost of the requested medium is significant (Compact Disc). Persons interested in receiving this data in conjunction with transportation data may contact the authors, other requests for this data and metadata should be directed to the EPA.

DATA MAINTENANCE

Money from DOH will be used in 1997-98 to integrate modeled WPZ data into the statewide data layer which is currently based on calculated fixed radius measurements. Further updates and revisions to CARA data may also be performed with these resources.

METADATA

DOT's metadata format is an MS Access product which is largely Federal Geographic Data Council compliant. This format is easily exported to a text file and was considered to be most accessible to the majority of users. Metadata will be distributed with each data request.

BENEFITS OF PROJECT

The gathered data has already been put to use by DOT in identification of highway stormwater outfalls which may affect drinking water supplies in Clark County; and prioritization of stormwater treatment system installation; and for assessment of potential water quality impacts from the 20 year State Transportation Plan.

This project has pointed out the variances in methodology currently used by counties to delineate critical aquifer recharge areas, and the need for good locational data for public drinking water wells. Many counties accelerated designation and mapping of CARAs due to the interest in this data generated by the Groundwater Project.

This project also provided partnership and data sharing opportunities with other state agencies and counties and is an example of success in implementing GIS within DOT. The following recommendations based on experience gained during the project may prove valuable to others who have responsibility for collating resource information for a statewide GIS data layer:

- Valuable support, feedback, and data can be gained through outreach; take every opportunity to present the project to peers and potential users.

- Put a representative sample of data to use early in the project to test for effectiveness and as a measure of success.

- Offering the finished data free-of-charge encourages cooperation within the GIS community and benefits advancements of GIS statewide.

AKNOWLEDGEMENTS
Appreciation is noted for the technical and advisory support given to this project by the IGWC, GIC, DOH, DOE, the pilot study data testers, Water Quality Specialists, Bert Bowen and Ed Molash of the Environmental Affairs Office within DOT and members of the DOT GIS Implementation Team. Thanks is also given to Environmental Systems Research Institute, producers of ArcInfo and ArcView software, for their technical advice and software support.